Transient paralysis from carbon dioxide angiography in a patient after four-vessel endovascular thoracoabdominal aortic aneurysm repair

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Contrast angiography with carbon dioxide (CO_2) is frequently used in patients with renal dysfunction or iodinated contrast allergies, as CO_2 is nonallergenic, nontoxic, and rapidly absorbed in the blood. However, when delivered intra-arterially, there is a possibility that CO_2 may create a vapor lock with resultant transient ischemia. We describe a case of suspected CO_2 embolus to the iliolumbar artery after iliac artery stenting resulting in immediate loss of bilateral lower extremity motor and sensory function. After placement of a spinal drain and elevation of mean arterial blood pressure, the patient had complete return of sensation with improvement in motor function. (J Vasc Surg 2012;56:1717-20.)

As endovascular techniques gain in popularity, the deleterious effects of iodinated contrast become more prevalent. Intravascular infusion of radiopaque contrast is the third leading cause of hospital-acquired acute renal failure.[1] Carbon dioxide (CO_2) is an inert, highly soluble gas that can be used as an alternative contrast medium with digital subtraction angiography (DSA), especially in patients with allergic reactions to iodinated contrast or poor renal function. CO_2 DSA is an acceptable method for endovascular techniques, including stent placement for abdominal aortic aneurysm, ruptured abdominal aortic aneurysm, and peripheral arterial disease.[2-4] There is no known toxicity after CO_2 injection and complications after CO_2 DSA are rare and mostly nonspecific to CO_2 contrast.[4]

A unique case of transient bilateral lower extremity paralysis after CO_2 DSA in a patient with a previous endovascular four-vessel thoracoabdominal aortic aneurysm (TAAA) repair is presented. To our knowledge, transient paralysis after infradiaphragmatic CO_2 angiography has never been previously reported.

CASE REPORT

A 67-year-old man presented with an acutely enlarging paravisceral aortic aneurysm and enlarging midthoracic aortic aneurysm. He had previously undergone open infrarenal abdominal aortic repair 7 years prior with an aorto-bi-iliac graft with distal anastomoses to bilateral common iliac arteries. After admission to the vascular surgery service, he was treated with surgeon-modified thoracic and fenestrated abdominal aortic endograft repairs. Vascular access for endograft placement was through a left flank retroperitoneal exposure due to severe angulation of previously placed aorto-bi-iliac graft limbs. Both iliac limbs of the graft were cannulated directly. His mid-descending thoracic aortic aneurysm was treated with a tapered thoracic endograft. The paravisceral aortic aneurysm required endovascular aneurysm repair with fenestrations for the superior mesenteric artery and right renal artery, snorkel graft for the celiac artery, and periscope graft to the left renal artery. Total endograft coverage extended from the proximal descending thoracic aorta to the midinfrarenal abdominal aortic graft. Postoperatively, the patient was ambulatory with no evidence of spinal cord ischemia.

The patient underwent routine surveillance computed tomography angiography (CTA) 13 days after TAAA repair, which demonstrated new kinking in the left iliac limb of the bifurcated graft from pulling the graft distally during endovascular TAAA repair, resulting in 80% stenosis. Additionally, an adjacent, chronic 70% stenosis was identified at the anastomosis of the left iliac limb of the graft to the native left common iliac artery (Fig 1). CTA of the head and neck demonstrated patent left vertebral artery and an occluded right vertebral artery with reconstitution at the C6 level. Due to the patient's decreased renal function after endovascular TAAA repair from an estimated glomerular filtration rate of 120 mL/min/1.73m^2 to 50 mL/min/1.73m^2 and recent iodinated contrast exposure from the CTA, the stenoses of the left iliac limb were repaired utilizing CO_2 angiography 15 days after completion of endovascular TAAA repair. Under conscious sedation, the left common femoral artery was accessed, and CO_2 DSA was performed confirming the two iliac limb stenoses identified on CTA. The CO_2 delivery system (Angio Flush III Contrast Management System; Angio Dynamics, Queensbury, NY) involved a 1500-cm^3

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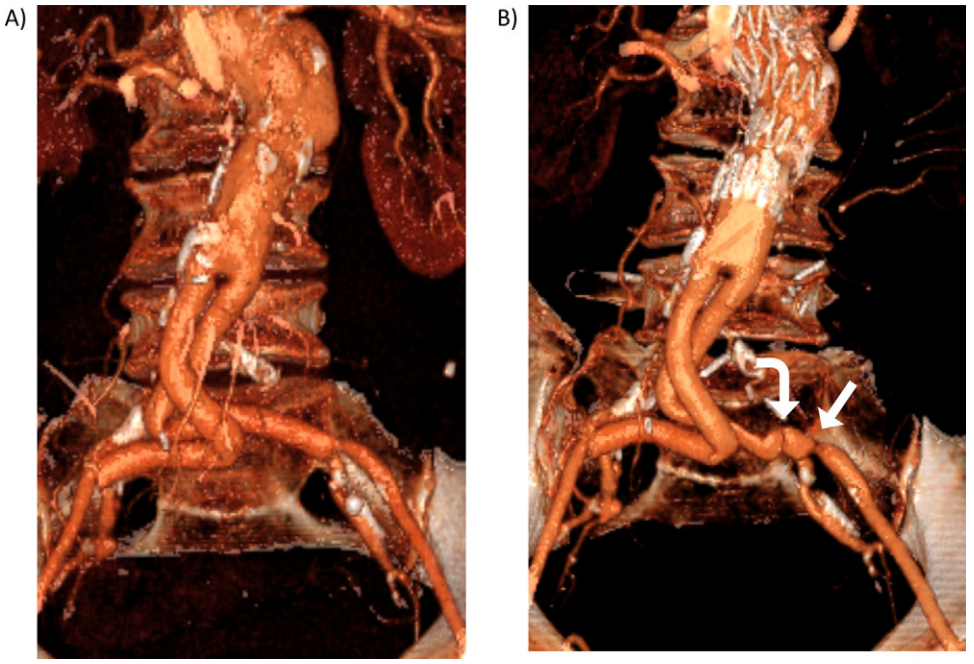

Fig 1. Three-dimensional reconstruction from computed tomography angiography (CTA) of the infrarenal abdominal aorta on patient presentation **(A)** and after endovascular repair **(B)**. After endovascular aneurysm repair, the left iliac limb of the aorto-bi-iliac graft had a kink with 80% stenosis (*curved white arrow*). Additionally, there was an adjacent, chronic 70% stenosis at the anastomosis of the left iliac limb with the patient's native common iliac artery (*white straight arrow*).

plastic collection bag with multiple one-way flow valves attached to a 60-mL Luer-lock syringe used for hand injections. The entire system was primed three times with CO_2 to eliminate all air from the closed system. A 10-mm × 60-mm Covidien Protégé (Mansfield, Mass) uncovered stent was advanced across both stenotic areas. CO_2 DSA was performed from the left iliac artery graft limb to confirm stent position. Following this, the patient was asked to move his lower extremities and was found to have loss of all motor and sensory function to his bilateral lower extremities in the procedure suite. The stent was quickly molded with balloon angioplasty, and contrast angiography was performed demonstrating resolution of the stenoses with continued patency of the left internal iliac artery (Fig 2). For stent placement, total contrast delivered was 300 mL of CO_2 contrast along with 50 mL of iodixanol as supplemental contrast agent for improved imaging. During the entire procedure, mean arterial pressures were >85 mm Hg. Given his history of extensive aortic coverage with endografts, a lumbar drain was urgently inserted and 10 mL of cerebrospinal fluid were drained. Additionally, vasopressor medications were initiated to raise mean arterial pressures. Within 1 hour, bilateral sensory function had returned. Concomitantly, motor function on the right side returned to near normal, and the left lower extremity regained crude motor function.

In the days following the procedure, his motor function improved slowly with physical therapy. The spinal drain was removed after 72 hours. Magnetic resonance imaging/magnetic resonance angiography was attempted to better define the spinal cord ischemic injury, but this study was unable to be performed due to scatter from the endograft stents. After 1 week of rehabilitation, he had regained nearly all strength in the right leg with some residual motor deficit in the left lower extremity. On the right, hip flexors were 2+/5, quadriceps was 4/5, and ankle dorsiflexion and plantar flexion were 4/5. On the left, both hip flexors and extensors were 2/5 and ankle dorsiflexion and plantar flexion were 0/5. He was discharged to a skilled nursing facility for further therapy, and he has since become ambulatory with mild assistance.

DISCUSSION

The case presented describes an episode of transient paralysis after CO_2 DSA most consistent with CO_2 embolus to the left iliolumbar artery. The iliolumbar artery is the first branch of the internal iliac that branches posteriorly and then divides into iliac and lumbar branches, providing collateral spinal perfusion (Fig 2). The patient had extensive coverage of his thoracic and abdominal aorta with endovascular stent placement, likely decreasing other spinal collateral perfusion. His contralateral internal iliac artery was widely patent. Following CO_2 injection, it is suspected that a small CO_2 embolus was trapped in the spinal collateral vessels from the left iliolumbar artery, resulting in transient spinal ischemia.

CO_2 DSA is increasingly prevalent for endovascular techniques as it provides a nonallergenic, non-nephrotoxic alternative that is 400 times less viscous than traditional contrast agents.[5] Furthermore, it is rapidly absorbed from the bloodstream by combining with the alkaline blood

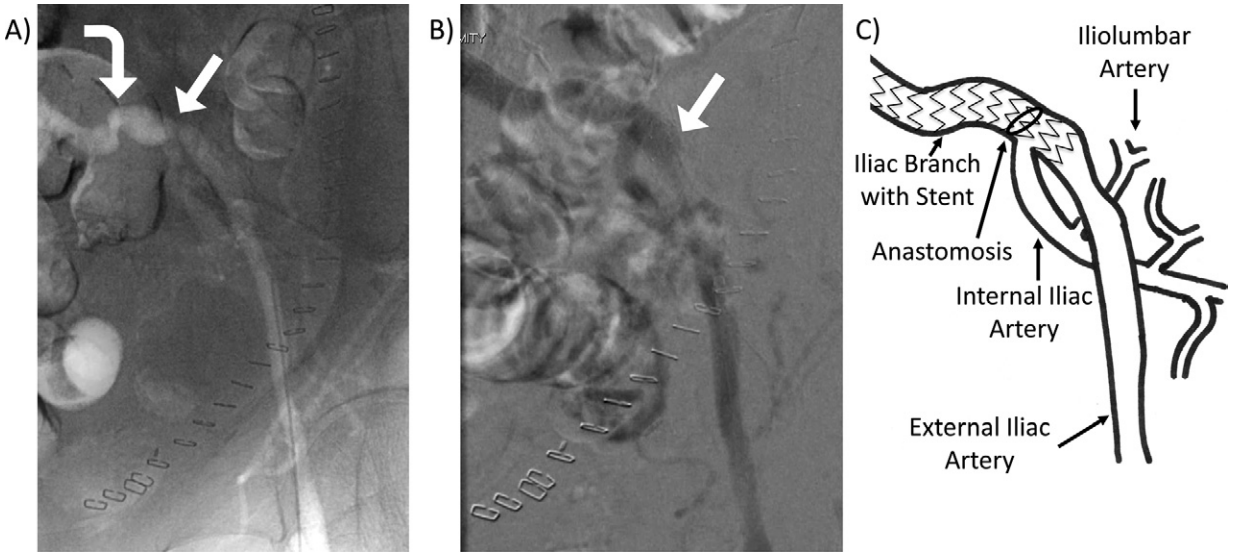

Fig 2. A, Carbon dioxide (CO_2) digital subtraction angiography (DSA) demonstrating kinking (*curved white arrow*) of the left limb of the iliac artery graft and chronic stenosis at the graft to common iliac artery anastomosis (*white straight arrow*). **B,** After uncovered stent placement, contrast angiogram was performed with filling of both the external and internal iliac arteries. The *white arrow* marks the termination of the iliac artery stent. Iodinated contrast used to supplement imaging with CO_2 DSA. **C,** Illustration of relevant anatomy.

buffer system and is eliminated by one pass through the pulmonary circulation. Since Hawkins' first description of CO_2 for angiography in 1982,[6] CO_2 DSA has been widely applied for arterial and venous imaging. Reports of adverse side effects are infrequent. Moos et al[4] reported a 6% complication rate in 1007 consecutive CO_2 DSA procedures, the majority being puncture site hematomas. However, deleterious side effects of intra-arterial CO_2 injection have been reported and are mostly related to the "vapor-lock" phenomenon. Although the gas is rapidly absorbed, CO_2 can be trapped in smaller vessels in the vasculature and cause transient ischemia. CO_2 vapor lock is believed to be responsible for 1% of patients experiencing abdominal pain after aortography and four cases of pancreatitis after CO_2 DSA. CO_2 vapor lock has also been implicated in three cases of intestinal ischemia: (1) a patient with livedo reticularis and intestinal infarction after intra-arterial injection of CO_2,[7] (2) transient right-sided colonic ischemia after CO_2 abdominal aortography,[8] and (3) transient left-sided colonic ischemia after CO_2 DSA.[9] Based on animal models, CO_2 has potential neurotoxicity with multifocal cerebral ischemic infarction after repeated injections of CO_2 into the carotid artery.[10,11] Due to the potential neurotoxicity of CO_2, its use has been typically reserved for infradiaphragmatic procedures.[12]

The current report details a patient experiencing transient paralysis after CO_2 DSA. Although the patient's clinical syndrome was most consistent with CO_2 embolization of the iliolumbar artery, it remains a suspected diagnosis, as a CO_2 embolus was not directly visualized. Other possible causes include decreased perfusion of the left internal iliac artery after stent placement, atherothrombotic embolization, and air contamination. The uncovered stent was placed across the anastomosis of the iliac limb of the aorto-bi-iliac graft with the native left common iliac with partial extension over the origin of the left internal iliac artery. However, excellent perfusion of the internal iliac artery was seen on angiography after stent placement (Fig 2). During the endovascular stent placement, it is also possible that atherothrombotic debris embolized into the left internal iliac artery. However, it would not be expected for paralysis after atherothrombotic embolization to rapidly resolve. Although our patient has not regained full strength of his left lower extremity, sensation and gross motor movement returned within 1 hour after CO_2 angiography. Last, air contamination of the CO_2 delivery system with subsequent air embolization is possible, although unlikely as the system is primed and has multiple one-way valves to prevent air contamination.

In conclusion, we present the first case of suspected CO_2 embolization resulting in transient paralysis after CO_2 DSA in a patient with endovascular TAAA repair. Surgeons must weigh the risk of potential paralysis with the renal benefits of CO_2 DSA in patients with previous extensive aortic coverage and, therefore, limited spinal collateral perfusion. If CO_2 DSA is performed in patients with extensive aortic endograft coverage, the treatment team may consider prophylactic spinal fluid drainage and limiting the volume of CO_2 injected.

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